ITRC PROJECT PROPOSAL: Multi-Increment Sampling (MIS)

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Please use brief statements or bullet items to input the requested information.

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Problem Statement (why is this project necessary?)

Quality control and reproducibility (i.e. scientific defensibility) are lacking in the sampling designs, strategies, and sample handling and processing protocols for environmental soil and sediment studies. Sampling theory and evidence indicate that the greatest bias and uncertainty in soil and sediment data quality is attributable to field sampling and laboratory sub-sampling, not laboratory instrumental error. Historically, quality control measures have focused on improving laboratory analytical procedures, resulting in very good reproducibility and QC of laboratory analyses. Quality control measures in field sampling design, strategy, and laboratory sub-sampling procedures have been neglected. The quality and information value of soil sampling data depends not only on laboratory analytical precision, but perhaps even to a greater degree on appropriate field sampling design and methodology to obtain scientifically defensible data that are relevant to the sampling objectives. Without the development and adoption of innovative sampling strategies that improve data reliability, the capabilities of modern laboratory measurement are underutilized, and progress toward cost-effective improvements in the reliability of site cleanup decisions is unlikely to be realized.

Conventional soil investigations typically rely on the collection of discrete surface soil samples from a site. Each sample is analyzed separately. The range of variability is often high and the reproducibility of duplicate samples notoriously poor due to the heterogeneous nature of soil (compositional heterogeneity) and the uneven distribution of contaminants across a site (distributional heterogeneity). Quite often, the results are compared to risk-based or regulatory values based on mean analyte concentration over a specific area (exposure unit). A large number of discrete analyses (typically more than 30), and corresponding large cost, can address distributional heterogeneity to obtain a statistically useful data set and estimate mean concentrations, but discrete samples do not address error due to compositional heterogeneity. In an effort to minimize costs, the number of samples all too often is reduced below the number required to demonstrate good statistical reproducibility. Statistical uncertainty (e.g. UCL95) is unnecessarily high. Additionally, statements of sampling objectives and sampling plans often do not specify requirements that ensure proper sample coverage, collection and processing procedures, or relevance of the data to inform project decisions. Together these factors contribute to high cost, decision uncertainty, and can lead to missed contamination or unnecessary cleanup.

Recently published EPA Method 8330B for explosive compounds, based largely on results of SERDP and ESTCP-funded programs, recommends the use of Multi-increment Sampling (MIS) procedures in both the field sample collection and laboratory sub-sampling to address the aforementioned problems. The remarkably improved reproducibility of results demonstrated by the development and proper application of MIS, and the precedent of recommended field sampling procedures for an EPA SW846 Method, has spurred interest in the approach throughout the environmental community. The laboratory procedures of 8330B were developed for the evaluation of explosive and propellant compounds. The field sampling objectives address range sustainability issues at active military firing ranges. Thus, the specific protocols developed are not necessarily directly transferable to studies having other objectives or other analytes; however, the underlying principles are critical to the scientific defensibility of all environmental studies. Although the need for scientifically defensible

(reproducible) soil and sediment data that meet sampling objectives at minimum cost is universal to soil investigations, guidance on the concepts underlying successful MIS design is not readily accessible.

Implementation of MIS has outpaced development of guidance and understanding of the underlying principles and concepts by the practitioners. A dozen or more state regulatory agencies are now requesting MIS for many DoD and other soil investigations, but only a handful have developed even limited guidance. Many MIS investigations and sampling plans are flawed and the data mis-directed or even misleading because of inadequate understanding of the fundamental requirements for correct application of the methodology. In some states, all composite sampling is perceived as diluting out “hot spots” or missing contamination. Some regulators have voiced concern that MIS loses spatial information.

Because of previous ill-conceived, uninformed, or mis-applied composite sampling, explicit regulatory barriers to its use exist. Deeply ingrained prejudice, misconceptions, and blanket prohibitions to "composite" sampling need to be overcome before MIS can be widely accepted. These barriers, biases, and misconceptions severely limit the use of one of the most cost-effective ways to improve environmental data quality.

Solution / Impact (how will the project impact the environmental marketplace?)

Multi-increment sampling (MIS) is a structured composite sample collection and processing approach designed to obtain a laboratory sub-sample for extraction having constituents in the same proportion as a specified area (volume) of soil or sediment about which a decision is to be made (i.e. the decision unit). The objective is to obtain a single sample for analysis that has a mean concentration representative of the decision unit. Mean concentration underlies the basis of many environmental decision criteria (risk-based screening levels, soil concentrations protective of groundwater, etc.) and is the most appropriate value on which to base most environmental decisions. The decision unit must be purposefully delineated so that the mean analyte concentrations obtained are directly relevant to well defined and explicitly articulated sampling objectives, including those investigating the spatial distribution of contaminants. Using MIS, reliable estimates of mean concentration for a specified area of virtually any size can be obtained from analysis of a single sample. Reproducibility between properly collected replicate MI samples is good (RSD/RPD <30 percent have been achieved). Data distribution of replicate samples tends to be normal (as opposed to positively skewed for discrete samples). Fewer non-detect results are obtained, thus mitigating the problems caused by censored data sets and lessening the chance of missing significant contamination (as defined in project DQOs). Levels of statistical confidence (UCL95) and decision uncertainty that would require a large number of discrete analyses often can be obtained with a few MI samples.

By developing guidance for the appropriate implementation of MIS to a wide range of sampling objectives, analytes, and circumstances, the project will improve data quality and reduce characterization costs at many sites where soil and sediment data are collected. The project will provide users with a practical working knowledge of the concepts and principles of the methodology, emphasize the critical importance of clearly articulated sampling objectives, and provide the sound basis for adapting the MIS approach to meet project goals and site-specific objectives. Sound guidance will help avoid misapplication and pitfalls of the approach, and correct misperceptions to overcome existing regulatory barriers and bias against well-conceived and properly applied composite sampling.

The project will be sharply focused on the MIS sampling methodology. It will capitalize on the successful demonstration/validation studies conducted by USACE/CRREL by developing broad guidance for implementation of MIS to a full range of analytes and a broad range of sampling objectives, and will parallel rapidly growing capability of commercial laboratories to meet the expanding use of the method.

Success Measures (how you determine the project impact to the market place)

- State concurrence with the Technical and Regulatory Guidance document will be an important measure of success. MIS is being applied in at least ten states, yet only two (AK and HI) are known have published even limited guidance. Because of the nearly universal need for improved soil and sediment data at reduced cost, the guidance is highly relevant. The number of states using MIS is growing rapidly, little guidance exists, thus a high level of concurrence with sound ITRC guidance might be anticipated. The challenge of overcoming regulatory barriers to composite sampling should not be underestimated by the team, however an increasing number of states are requesting, and even requiring the use of MIS in some instances.

- Because soil and sediment sampling is a fundamental component of so many environmental investigations, participation in a long-running internet training, which is easily tracked, can be expected to be high.

- Case studies showing demonstrated cost savings by improved systematic planning an use of MIS of soil investigations to obtain soil data supporting project decisions will be tracked to the degree possible.

- Use of ITRC MIS Technical and Regulatory Guidance in conjunction with, or in lieu of state or other guidance will be tracked to the extent possible. DoD representation and established networking of team members within the community of practice should provide success stories on DoD facilities.

Summary of Deliverables (primary project outputs)

- To begin addressing the need for sound information on MIS, example posters and fact sheets developed for presentations and meetings by team members working on MIS over the last few years will be adapted for ITRC use, and made available on the web through the team page.

- "An Overview of Multi-increment Sampling: pitfalls, and potential" will be made available as soon as possible to fill the pressing need for information on MIS recognized throughout the community of practice. Existing case studies, both good examples and "lessons learned", will be presented. Cost information is available for some. The overview will include comprehensive references and be resource for information on the existing body of knowledge. If timing permits, results of a survey on the regulatory status and extent of use of MIS will be included.

- The primary product will be the ITRC "Technical and Regulatory Guidance for the Implementation and Use of Multi-Increment Soil Sampling". The document will begin with discussion of heterogeneity – the primary source of error (variability) in soil sampling data, and the ways in which MIS effectively mitigates the difficulties posed by heterogeneity. This will be followed by guidance on formulating quantitative sampling objectives, focusing on sample "effectiveness" and data relevance to the objectives, and the use of MIS to meet those objectives. It will include critical discussion on the underlying basis of common decision criteria against which soil data are evaluated, and development of explicit DQOs not just for laboratory QC, but also for end use of the data and quantifying ultimate decision uncertainty. Considerations for three-dimensional applications (sub-surface soil) will be included, and analyte and method-specific collection, handling, and laboratory processing and sub-sampling requirements also will be addressed. I short, all of the considerations necessary to guide sampling design and execution for a successful MIS project will be covered.

- Internet-based training based on the Tech-Reg and of the same title will be developed concurrently with the Tech-Reg document.

Presentations and training on MIS as applied to munitions constituents at DoD sites, already are being given at meetings and conferences by team members. These will continue and expand to include other constituents and the full spectrum of objectives and analytes as work progresses.

Project Schedule

Because the scope of the project is well defined, and because key participants and subject matter experts already developing MIS techniques and guidance are willing to participate, a delivery time frame of 24 months to the implementation phase of the project life cycle is anticipated.

2009

- Early 2009 – 1st team meeting/kickoff. Consolidate team knowledge base. Many identified team members already have substantial knowledge and materials on the subject. Because MIS is relatively new, research is ongoing (some by team members), and new information continues to be gained at a rapid rate, team knowledge will continue to increase throughout the project life-cycle. Develop detailed project work plan; begin tracking and progress reports to Board Team Leader Liaison.
- Early 2009 – Adapt existing posters and fact sheets to ITRC format and audience for posting on ITRC team web site. Design state regulator survey.
- Early to mid 2009 – Conduct survey of the state regulatory status and concerns that might prohibit or impede the use of properly designed MIS for appropriate objectives. Regulatory barriers and impediments, and their origin and basis, will be particularly addressed in team documents. Collect and review case studies.
- Early to Mid-2009 – 2nd team meeting (May?) Organize and analyze results of survey. Develop outline and assign portions of the overview document to various co-authors.
- Late 2009 – Fall meeting (3rd team meeting) – Draft final overview document ready for courtesy review and start work on the Tech-Reg.
- Dec 2009 or Jan 2010 – Deliver final overview document.

2010

- Early to mid 2010 - Continue Tech-Reg guidance document and outline IBT.
- 4th team meeting (Feb?) – continue work on Tech-Reg. Begin slides for IBT.
- Mid 2010 – 5th team meeting (May/June?) – finalize Draft Tech-Reg for POC / DoD review
- Mid to late- 2010 Train-the-trainer internet training practice
- Late 2010 – Fall Meeting (6th team meeting)
- End 2010 - Deliver Final Tech- Reg document for publication and POC internet training dry run.

2011

- Implementation phase. Close-out and implementation strategy meeting 7th team meeting. Actively pursue concurrence from states and evaluate success of project. Continue internet training as demand warrants.

Target Audience

The primary target audience is twofold:

- state and federal regulators, project managers, and consultant personnel who are responsible for and/or directly involved in identifying soil and sediment sampling objectives and methodologies. This includes policy makers and data end users (e.g. risk assessors). The work products will be useful for developing technical and regulatory decision processes without specialized technical skill sets.

- personnel directly responsible for developing, implementing, and overseeing specific sampling strategies and field sampling plans to meet those objectives. Specific examples and case studies will be provided.

Secondary audiences will be

- field personnel who should have an understanding of the basic concepts underlying activities they are performing to recognize potential problems that may arise during sampling, and

- decision makers/upper management personnel and stakeholders who should have an understanding of the nature and quality of the soil and sediment data upon which environmental decisions are based.

Resources Required

Personnel: Note: A team leader from a state regulatory agency has not yet been identified.

State Representatives

Email confirmation of intent to participate, and management support from:

- Roger Brewer, Hawaii Dept. of Health
- Earl Crapps, Alaska Dept of Environmental Conservation
- Jeffrey E. Patterson, Texas Commission on Environmental Quality
- Jeanene Hanley, Arizona Dept of Environmental Quality

Verbal expression of interest in participation and likely management support:

- Matt Thomas, Alabama Dept of Environmental Management
- Craig Kleinhenz, Ohio EPA, Criminal Investigations

Industry Affiliates

Email confirmation of interest in participation and willingness to join IAP:

- Larry Penfold, Federal Program Quality Manger, TestAmerica, Inc. – Denver
- Mark Bruce, Technical Director, TestAmerica, Inc. – North Canton. OH

DoD

Email confirmation of intent to participate from:

- Alan D. Hewitt, USACE/CRREL
- Edward J. Brown, Environmental Chemist, AFCEE
- Keith Hoddinott, Risk Assessor, US Army CHPPM

Intent for Navy participation from:

- Ed Hartzog, Director, Laboratory Quality and Accreditation Office NAVSEA Programs; Chairperson, Tri-Services Environmental Data Quality Workgroup (EDQW)
- Jordan Adelson, NAVSEA Laboratory Quality and Accreditation Office
- Ed Corl, Chemist, EDQW

EPA

Verbal confirmation of participation and management support:

- John Warren, statistician, US EPA (HQ), Quality Staff, Office of Environmental Information

Current members of the ITRC Risk Assessment Team, UXO Team, and Sampling, Characterization and Monitoring Team have expressed interest and may be expected to in participate on this proposed project if it is approved.

Related Work:

The MI sampling approach is relevant to projects and work products of the ITRC Risk Assessment Team; UXO Team; and Contaminated Sediments Team. MIS products would be integrated or referenced by each of these teams. The broad range of environmental applications for MIS, its recent and rapid emergence, and the in-depth treatment and expertise that comprehensive guidance will require, have been beyond the scope of the individual teams. Several current members of those teams have expressed interest in participating and contributing to guidance development from their perspective for MIS.

Other identified ITRC priorities for 2009 related to MIS include:

- Remediation Risk Management Team —Risk-based decision making for land re-use.
- Soils Risk Management – upland soil contamination and risk based clean up objectives.

The concurrent ITRC proposal “A Guide to Munitions Constituents Regulatory Status, Sampling, and Treatment” has some overlap with this proposal. Proponents have discussed coordination on subject matter

common to these complementary projects, and possibly having team members in common to maximize benefit from both team efforts. The full range of applications for multi-increment sampling has broader requirements, and warrants more in-depth treatment than the overview discussion now planned for the munitions constituents guidance.

Current ESTCP proposals 09 E-ER1-009 "Demonstration of the Attributes of Multi-Increment Sampling and Proper Sample Processing Protocols for the Characterization of Metals on DoD Facilities" (Alan D. Hewitt). Note: Proponent intends to participate on this ITRC project if it goes forward.

The proposed MIS project will build directly on work successfully performed under ESTCP Project ER-0628 "Characterization of Energetic Residues on Military Training Ranges" (Alan D. Hewitt), and SERDP Projects ER-1155 and 1481.

The Tri-Services Environmental Data Quality Workgroup is developing "Guide for Implementing EPA SW-846 Method 8330B". Document discusses considerations in the use of 8330B and application of MIS to other contaminants and applications. EDQW (Navy) intends to participate on this ITRC project if it goes forward.

In response to requests and requirements by a growing number of state regulatory agencies to implement MIS, the Army Corps of Engineers is currently developing an interim guidance for the implementation of MIS in at Formerly Used Defense Sites (FUDS).

Update of the EPA Handbook on the Management of Munitions Response Action EPA 505-B-01-001, May 2005, (interim final) has just begun. Among the updates is inclusion of MIS methodology based on the USACE/CRREL work, but it will not involve in-depth discussion of MIS principles and concepts necessary to adapt the technique to a broad spectrum of environmental investigations. Proposed team members are involved and EPA Federal Facilities personnel may become involved.

A draft EPA Federal Facilities Forum Issue Paper tentatively titled "Sampling Design and Analysis of Munitions Residues on Ranges and Open Burn/Open Detonation Units" has been in development since 2006.